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CLINICAL RESEARCH

Characteristics of diabetic patients and diabetes care in cardiac rehabilitation



Profil des patients diabétiques et prise en charge du diabète en réadaptation cardiaque

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Summary

Background. — Although diabetes is associated with a high cardiovascular risk, very little information is available about diabetic patients enrolled in cardiac rehabilitation (CR).

Aims. — To analyse the characteristics of diabetic patients and diabetes care in CR.

Methods. — From the database of 700 patients enrolled in CR during a 29-month period, we analysed data from all patients with glucose metabolism disorders ($n = 105$) and 210 matched normoglycaemic patients.

Results. — A total of 105 patients with glucose metabolism disorders (type 1 diabetes, $n = 5$; type 2 diabetes, $n = 84$; impaired fasting glucose, $n = 16$) were enrolled in a CR programme (15% of whole population). Fifteen per cent of patients with type 2 diabetes and all patients with impaired fasting glucose were diagnosed during CR. These 105 patients were older and had a higher body mass index, a larger waist circumference, higher fasting blood glucose and triglyceride concentrations and lower low-density lipoprotein cholesterol concentrations than

Abbreviations: ACE, acute coronary event; CR, cardiac rehabilitation; HbA_{1c}, glycated haemoglobin; LDL, low-density lipoprotein; VO₂, oxygen consumption.

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MOTS CLÉS

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non-diabetic patients; they also had higher rates of hypertension ($P=0.001$) and dyslipidaemia ($P=0.02$). They were more frequently referred to CR for peripheral artery disease ($P=0.001$), coronary heart disease + peripheral artery disease ($P=0.007$) and primary prevention ($P=0.009$). The intervention of a diabetologist was needed for 42.6% of patients because of uncontrolled or newly diagnosed diabetes.

Conclusion. — In the present study, we showed that (1) the proportion of patients with diabetes in CR is lower than expected, (2) many glucose metabolism disorders are diagnosed during CR, (3) patients with glucose metabolism disorders show a more severe cardiovascular risk profile than normoglycemic patients, and (4) the intervention of a diabetologist is needed during CR for many patients with diabetes.

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Résumé

Contexte. — Bien que le diabète soit associé à un risque cardiovasculaire élevé, la situation des patients diabétiques en réadaptation cardiaque (RC) reste mal connue.

Objectif. — Analyser les caractéristiques des patients diabétiques et la prise en charge du diabète en RC.

Méthodes. — À partir d'une base de données de 700 patients admis en RC au cours d'une période de 29 mois, nous avons étudié les données de tous les patients avec anomalies du métabolisme glucidique ($n=105$) et de 210 patients normoglycémiques appariés.

Résultats. — 105 patients avec anomalies du métabolisme glucidique (5 diabète de type 1, 84 diabète de type 2, 16 hyperglycémies à jeun non diabétiques) ont été admis en RC, soit 15% de l'ensemble de la population. Quinze pour cent des diabètes de type 2 et toutes les hyperglycémies à jeun non diabétiques ont été diagnostiqués en RC. Ces 105 patients étaient plus âgés, plus hypertendus et présentaient des valeurs plus élevées de BMI, tour de taille, glycémie à jeun, triglycérides et des valeurs plus basses de LDL-cholestérol comparés aux patients non diabétiques. Ils étaient plus fréquemment admis en RC pour artériopathie des membres inférieurs (AMI) ($p=0,001$), coronaropathie + AMI ($p=0,007$) ou prévention primaire ($p=0,009$). Pour 42,6% des patients, l'intervention d'un diabétologue fut nécessaire en raison de mauvais contrôle du diabète ou de découverte de diabète.

Conclusion. — Notre étude montre que : (1) la proportion des patients diabétiques en RC est plus faible qu'attendu ; (2) Plusieurs anomalies du métabolisme glucidique sont diagnostiquées au cours de la RC ; (3) les patients avec anomalies du métabolisme glucidique admis en RC ont profil cardiovasculaire plus sévère que les non diabétiques ; et (4) que l'intervention d'un diabétologue au cours de la RC est nécessaire pour de nombreux patients diabétiques.

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Background

Diabetic patients are at increased risk of coronary heart disease, heart failure and stroke. Cardiovascular disease in diabetic patients is also more severe, with significantly higher rates of morbidity and mortality compared to cardiovascular patients without diabetes [1,2]. Several studies have clearly shown that cardiac rehabilitation (CR) significantly reduces cardiovascular morbidity and mortality and improves quality of life [3–5]. The first meta-analyses clearly demonstrated that CR after myocardial infarction significantly reduced cardiovascular morbidity and mortality [3,4,6]. This clear beneficial effect of CR on overall mortality and cardiovascular mortality was confirmed subsequently by several clinical trials [7,8] and meta-analyses [5,9,10]. The cardiovascular mortality rate in patients who underwent CR with exercise training after myocardial infarction was found to be 20–26% lower than in those who did not have CR [3,4,10]. Long-term reductions in cardiovascular mortality and total mortality after CR were confirmed by Hedbäck

et al., who showed a 26.7% reduction in total mortality and a 27.1% reduction in cardiovascular mortality over a 10-year period [11]. Hence, CR programmes are recognized as an integral part of the care strategy for patients with coronary heart disease, heart failure, cardiac surgery and peripheral artery disease, and CR is a level A recommendation in patients with coronary heart disease [12–17].

CR is strongly recommended for both primary and secondary prevention in patients with type 2 diabetes because of their high cardiovascular risk. However, little is known about diabetic patients who undergo CR. For instance, it is not clearly known whether diabetic patients referred for CR are representative of all diabetic individuals and whether there are differences compared with non-diabetic patients referred for CR. In addition, there are no data on glycaemic control during CR, and the percentage of patients who are referred to a diabetologist for uncontrolled diabetes is unknown. This lack of knowledge prompted us to perform a retrospective study to analyse the characteristics of diabetic patients enrolled in CR, including clinical

and biological features, cardiovascular complications, other diabetes-related complications, indications for CR, diabetes care in CR and situations in which referral to a diabetologist was needed.

Methods

Patients

From the database of the 700 patients enrolled in a comprehensive CR programme in a CR centre (clinique des Rosiers, Dijon) from September 2008 to February 2011, we retrospectively reviewed data from all patients with diabetes or fasting hyperglycaemia ($n=105$). In addition, for each patient with a glucose metabolism disorder (diabetes or fasting hyperglycaemia), we selected, by drawing lots, two normoglycaemic patients enrolled in the same CR programme during the same month, in order to have a randomized control group of 210 individuals.

All of the patients were enrolled in an outpatient CR programme consisting of 20 physical training sessions, an individualized educational programme (nutrition, management and control of cardiovascular risk factors to reach the goals of secondary prevention, stress management, smoking cessation), psychological support, and help with occupational and work reintegration.

During the programme, all patients had a regular cardiac follow-up (once a week), to assess cardiac treatment, patient motivation and cardiovascular risks factors, and to supervise training sessions. A multidisciplinary meeting was held each week. Diabetic patients had a careful follow-up that included blood glucose monitoring during training sessions, modifications of antidiabetic treatments when needed, a specific group educational course and nutritional counselling.

Data collection

For all of the patients, we collected baseline clinical and biological characteristics, indications for CR and cardiovascular risk factors (hypertension, smoking, dyslipidaemia). Patients were considered dyslipidaemic when plasma low-density lipoprotein (LDL)-cholesterol or triglyceride concentrations were above the recommended target or when they were taking hypolipidaemic agents. Data on diabetes, including type of diabetes, duration of diabetes, treatment, complications and need to be referred to a diabetologist during the CR programme, were also collected.

Coronary heart disease was defined as the occurrence of an acute coronary event (ACE), angina pectoris, the presence of coronary artery occlusion on the coronary angiogram, percutaneous coronary intervention with stent placement, or coronary artery bypass surgery. Peripheral artery disease was defined as the presence of intermittent claudication, a history of limb artery surgery, or an abnormal lower limb Doppler ultrasound scan.

Statistical analysis

Data are expressed as mean \pm standard deviations for quantitative variables and as percentages for qualitative

variables. The two populations were compared using the Chi² test for qualitative variables and Student's *t* test for quantitative variables. A *P* value < 0.05 was considered statistically significant. Statistical calculations were performed using the SPSS software package (Chicago, IL, USA).

Results

Clinical and biological characteristics and cardiovascular risk factors

During the 29-month study period, 105 patients with glucose metabolism disorders (22 women and 83 men) were enrolled in the CR programme. This number represented 15% of the whole population ($n=700$) enrolled in CR during the same period.

The 105 patients with glucose metabolism disorders included five patients with type 1 diabetes (5%), 84 patients with type 2 diabetes (80%) and 16 patients with impaired fasting glucose (15%). Among the 84 patients with type 2 diabetes, 13 were diagnosed with type 2 diabetes (15%) during the CR. All of the patients with impaired fasting glucose were diagnosed during the CR. Among the 105 patients with glucose metabolism disorders, 29 (27.6%) were diagnosed during the CR.

The 105 patients with glucose metabolism disorders were compared with 210 normoglycaemic patients (54 women and 156 men) enrolled in the CR programme, during the same period (ratio 1:2). The main characteristics of the patients with glucose metabolism disorders and normoglycaemic patients are shown in Table 1. Patients with glucose metabolism disorders were older than normoglycaemic patients (63.31 ± 12.38 vs. 60.92 ± 9.87 years; $P=0.038$) and had a higher body mass index and waist circumference. They also had higher fasting blood glucose and triglyceride concentrations, lower LDL-cholesterol concentrations and a more severe cardiovascular risk profile, with a greater proportion of patients with hypertension ($P=0.001$) and dyslipidaemia ($P=0.02$). Patients with glucose metabolism disorders had a lower baseline cycloergometer workload than normoglycaemic patients.

Referral to cardiac rehabilitation

Indications for CR are shown in Table 2. Patients with glucose metabolism disorders were more frequently referred for CR for peripheral artery disease ($P=0.001$), coronary heart disease + peripheral artery disease ($P=0.007$), and primary prevention ($P=0.009$) compared with normoglycaemic patients.

The type of medical doctor (cardiologist, heart surgeon, other medical doctor) who referred patients for CR was similar for patients with glucose metabolism disorders and normoglycaemic patients. Most patients were referred by cardiologists (74% of patients with glucose metabolism disorders and 72% of normoglycaemic patients) or heart surgeons (19% of patients with glucose metabolism disorders and 25% of normoglycaemic patients). The other medical doctors who referred patients for CR were general practitioners, diabetologists, nephrologists and angiologists.

Table 1 Main clinical and biological characteristics and risk factors.

	Normoglycaemic patients (n = 210)	Patients with glucose metabolism disorders (n = 105)	P
Age (years)	60.92 ± 9.87	63.31 ± 12.38	0.038
Men	156 (74.3)	83 (79.0)	0.35
Weight (kg)	78.97 ± 15.61	87.53 ± 15.10	< 0.001
Height (cm)	168.94 ± 14.18	169.21 ± 9.85	0.86
BMI (kg/m ²)	28.53 ± 13.38	29.96 ± 5.01	0.29
Waist circumference (cm)	97.96 ± 11.25	107.25 ± 13.25	< 0.001
Fasting blood glucose (mmol/L)	5.27 ± 0.50	7.49 ± 2.11	< 0.001
Total cholesterol (mmol/L)	4.26 ± 1.11	4.13 ± 1.08	0.37
LDL-cholesterol (mmol/L)	2.43 ± 0.95	2.17 ± 0.77	0.01
HDL-cholesterol (mmol/L)	1.21 ± 0.36	1.14 ± 0.28	0.10
Triglycerides (mmol/L)	1.37 ± 0.70	1.92 ± 1.86	0.005
Creatinine (μmol/L)	92.75 ± 47.61	88.61 ± 22.38	0.40
Hypertension	124 (59)	82 (78)	0.001
Dyslipidaemia	180 (86)	99 (94)	0.02
Tobacco smoking	50 (24)	23 (22)	0.71
Statin treatment	201 (96)	100 (95)	0.85
ACEI/ARB treatment	184 (88)	95 (90)	0.45
Beta-blocker treatment	176 (84)	87 (83)	0.83
Antiplatelet agent treatment	210 (100)	105 (100)	1
Cycloergometer peak workload (W)	94 ± 32	83 ± 28	0.002

Data are mean ± standard deviation or number (%). ACEI: angiotensin-converting enzyme inhibitor; ARB: angiotensin II receptor blocker; BMI: body mass index; HDL: high-density lipoprotein; LDL: low-density lipoprotein.

Diabetic complications in patients enrolled in cardiac rehabilitation

As far as microvascular complications were concerned, 5% of the diabetic patients had retinopathy, 21% had nephropathy and 17% had neuropathy. In terms of macrovascular complications, 91% of the diabetic patients had coronary heart disease and 30% had peripheral artery disease.

Treatment of diabetes at time of enrolment in cardiac rehabilitation

Antidiabetic treatment at time of enrolment in the CR programme in patients with diabetes is shown in [Fig. 1](#): 18% of patients had no antidiabetic treatment, 45% had oral antidiabetic drugs (OADs) only, 18% had an OAD plus insulin combination, 18% had basal-bolus insulin therapy, and 1%

Table 2 Indications for cardiac rehabilitation.

	Normoglycaemic patients (n = 210)	Patients with glucose metabolism disorders (n = 105)	P
Indication, n (%)			
Coronary heart disease	165 (78.5)	81 (77.1)	0.85
Stable angina	46 (21.9)	31 (29.5)	0.14
Acute coronary event	94 (44.7)	33 (31.4)	0.02
Asymptomatic	25 (11.9)	17 (16.2)	0.29
Stent(s)	102 (48.5)	51 (48.5)	1
Coronary artery bypass surgery	57 (27.1)	28 (26.6)	0.92
Coronary heart disease + peripheral artery disease	10 (4.8)	14 (13.3)	0.007
Coronary heart disease + aortic valve replacement	8 (3.8)	6 (5.7)	0.85
Aortic valve replacement	25 (11.9)	10 (9.5)	0.52
Peripheral artery disease	16 (7.6)	21 (20.0)	0.001
Dilated cardiomyopathy	14 (6.7)	5 (4.8)	0.50
Mitral valve replacement	10 (4.8)	2 (1.9)	0.21
Cardiac rhythm disorder	17 (8.1)	7 (6.7)	0.65
Primary prevention	1 (0.5)	5 (4.8)	0.009
Congenital heart disease	3 (1.4)	0 (0)	0.22

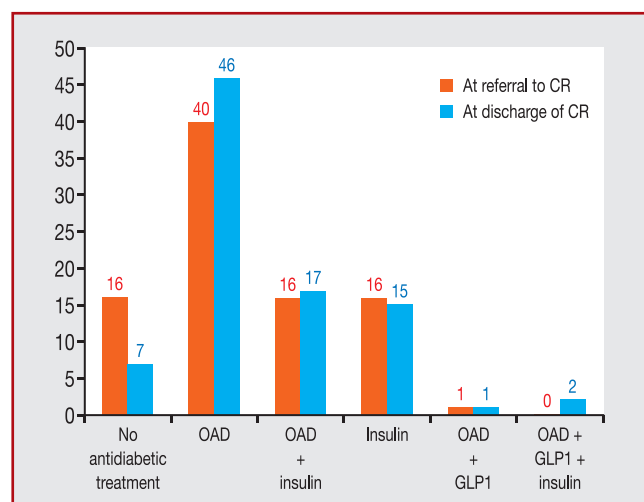


Figure 1. Antidiabetic treatments at referral and at discharge from cardiac rehabilitation (CR) programme. GLP-1: glucagon-like peptide 1 analogue; OAD: oral antidiabetic drug.

had an OAD plus glucagon-like peptide 1 analogue combination.

Referral to a diabetologist during cardiac rehabilitation

During CR, the intervention of a diabetologist was needed for 42.6% of the patients with diabetes. A patient with diabetes was referred to a diabetologist when diabetes was diagnosed during CR and in situations of uncontrolled diabetes (glycated haemoglobin [HbA_{1c}] $\geq 7.05\%$) and/or frequent hypoglycaemic events. This intervention took the form of telephone advice in 12.3% of patients, a consultation in 13.5% of patients, a 1-day outpatient hospitalization in the diabetology department for 12.3% of patients and inpatient hospitalization in the diabetology department for several days for 4.5% of patients (Fig. 2).

Mean HbA_{1c} according to the type of intervention by the diabetologist is also shown in Fig. 2. Mean HbA_{1c} was significantly higher in diabetic patients for whom specialized

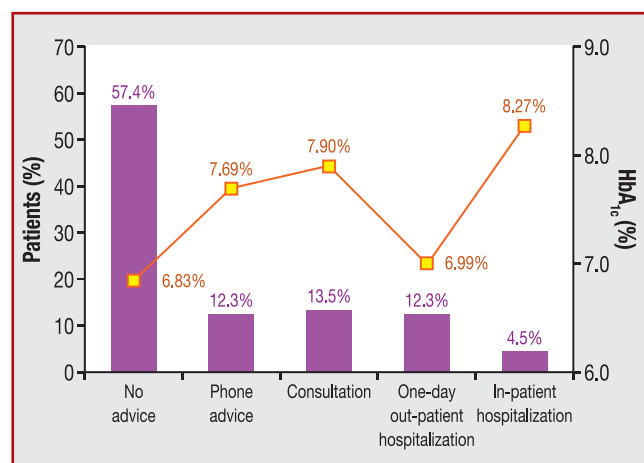


Figure 2. Referral to a diabetologist during cardiac rehabilitation and mean glycated haemoglobin (HbA_{1c}).

advice was needed: 7.71% vs. 6.83% ($P < 0.001$). Mean HbA_{1c} was not very high (6.99%) in patients who were hospitalized for one day. However, most of these patients had newly diagnosed diabetes, which explains why the mean HbA_{1c} was only moderately high. For these patients with newly diagnosed diabetes, the 1-day hospitalization was organized to perform a complete check-up for diabetes complications and also for educational purposes.

Treatment of diabetes at discharge from cardiac rehabilitation programme

For patients with diabetes, antidiabetic treatment at discharge from the CR programme is shown in Fig. 1. The percentage of patients receiving antidiabetic treatment at the end of the CR programme was significantly higher than at the beginning of CR (92% vs. 82%; $P = 0.04$).

Discussion

CR is recognized as an integral part of the care strategy for patients with coronary heart disease, heart failure and peripheral artery disease, and for those who have undergone cardiac surgery. Although cardiovascular disease is the main cause of mortality in diabetic patients, very few data are available for patients with diabetes enrolled in CR.

Our present study is the first to show the clinical and biological characteristics of diabetic patients enrolled in a CR programme, the indications for CR, diabetes care in CR and the situations for which referral to a diabetologist is needed.

First of all, the percentage of patients with glucose metabolism disorders referred for CR is low. Indeed, 105 patients with diabetes ($n = 89$) or impaired fasting glucose ($n = 16$) were included in our study. This represented only 15% of patients referred for CR during the same period. When considering only patients with diabetes, they accounted for only 12% of patients referred for CR. This proportion of patients with diabetes in CR is very low and much lower than expected given the high percentage of patients with diabetes hospitalized for ACEs. Indeed, in a study conducted in 999 patients hospitalized for ACEs, Zeller et al. showed that 53% had metabolism disorders (38% with diabetes and 15% with impaired fasting glucose) [18]. Our data showing a low rate of patients with diabetes in CR are in accordance with several other studies. For instance, Jeger et al., from a population of 1061 patients referred for CR during a 4-year period, reported only 15% of patients with diabetes [19]. Suresh et al. reported that among 1804 patients who attended CR during 10 years, only 12.4% had diabetes [20]. Hindman et al. reported that among the 1505 patients who attended their CR programme, 19% had diabetes [21]. Analysing the large Medicare database, Suaya et al. reported that the proportion of patients with diabetes was low [22]. Both Suaya et al. and Dunlay et al. demonstrated that diabetes was associated with a significant lower rate of attendance at a CR programme [22,23]. In a study by Dunlay et al., the absence of diabetes increased the referral rate for CR by a factor of 2.5 [23], which is in line with our present results. It has also been shown that other populations, such as women, elderly patients and patients with

multiple comorbidities, are less likely to be referred for CR [22]. Several studies have shown that the support of cardiologists is essential for referral for CR [23–25]. We may suppose that some cardiologists, who are the main prescribers of CR, might consider that CR is not suitable for extremely fragile patients, including patients with diabetes. However, it has been shown that all populations, including the more fragile patients, benefit from CR [26]. Our group has previously shown that CR is also effective in patients with diabetes and that improvement in oxygen consumption (VO_2) after CR is inversely associated with HbA_{1c} [27]. The direct effect of strict glycaemic control on VO_2 improvement after CR in patients with type 2 diabetes after an ACE is presently being investigated in the DARE study. In addition, as previously reported by others [28–31], our diabetic patients enrolled in CR carried a high cardiovascular risk and included a higher proportion of patients with hypertension and dyslipidaemia. This reinforces the fact that patients with diabetes, who have a high cardiovascular risk, are well suited to CR.

Another interesting point is the fact that 27.6% of patients with abnormal glucose disorders were diagnosed during CR, including all of the patients with impaired fasting glucose and 15% of the patients with type 2 diabetes. Newly detected abnormal glucose tolerance has been reported to be a strong independent risk factor for mortality and morbidity after myocardial infarction [32]. Thus, it seems important to detect such abnormal glucose disorders, including impaired fasting glucose, after any coronary event. This indicates that CR programmes provide an excellent opportunity to diagnose glucose metabolism disorders in patients with cardiovascular disease. The diagnosis of glucose metabolism disorders is not always made during hospitalization for an ACE [33]. It is for this reason that recent Société française du diabète (SFD)/Société française de cardiologie (SFC) guidelines recommend performing an oral glucose tolerance test between week 1 and week 4 after the ACE [34]. As CR often starts during the month following the ACE, we think that the CR period may provide a good opportunity to perform the oral glucose tolerance test.

Regarding the indications for CR, we found some significant differences between patients with glucose metabolism disorders and normoglycaemic patients. Indeed, diabetic patients are more frequently referred for CR for peripheral artery disease and coronary heart disease plus peripheral artery disease. Once again, these data underline the high frequency of the multiple vascular disorders in diabetic patients. Interestingly, we showed that patients with metabolism disorders are more frequently referred for CR for primary prevention. This may suggest that cardiologists, diabetologists and general practitioners are becoming aware of the benefits of CR for primary prevention in diabetes.

In the present study, we showed that the intervention of a diabetologist was needed during CR for more than 40% of the patients with diabetes because of uncontrolled or newly diagnosed diabetes. This finding emphasizes the need for collaboration between diabetologists and cardiologists involved in CR, as recommended by the recent 'consensus statement on care of the hyperglycaemic/diabetic patient during and in the immediate follow-up of an acute coronary syndrome' by the SFD/SFC [34]. In our present study, the efficacy of the collaboration between cardiologists involved

in CR and diabetologists is underlined by the fact that significantly more patients with diabetes had an antidiabetic treatment at the end of CR programme than at the beginning.

One limitation of the present study is that it is a single-centre study and the results might not be entirely applicable to other institutions.

Conclusions

The number of patients with diabetes referred for CR was much lower than expected in our study, and these patients had a more severe cardiovascular risk profile than normoglycaemic patients enrolled in CR. We also showed that many glucose metabolism disorders are diagnosed during CR and that the intervention of a diabetologist is needed during CR for more than 40% of the patients with diabetes. Cardiologists involved in CR have the opportunity to diagnose glucose metabolism disorders (including diabetes) and offer patients the most effective management through a beneficial collaboration with diabetologists.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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